Modelling of growth cycle of water hyacinth: An application to Bolgoda Lake

By

Miss. P. U. Dilani Fernando

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Department of Civil Engineering, University of Moratuwa, Sri Lanka

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DECLARATION

I hereby declare that the work included in the thesis in part or whole has not been submitted in any form for any other academic qualification of any institution.

P. Dilani Fernando

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Miss. P. U. Dilani Fernando

Certified by

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Dr. Mahesh Jayaweera

Supervisor

ABSTRACT

Water hyacinth (*Eichhornia crassipes* (Mart). Solms) is considered as a problematic aquatic weed in many lakes, irrigation canals, stagnant ponds, waterways and semi-wet areas in Sri Lanka. Bolgoda Lake is one of the freshwater bodies in Sri Lanka, which has been severely affected by excessive growth of water hyacinth thereby clogging the water ways and hence adversely affecting water quality. This study was conducted to determine the growth characteristic of water hyacinth under influence of natural, physical and chemical factors in Bolgoda Lake. The parameters considered in the study were as follows: biomass in dry weight, biomass production per day, phosphorus and nitrogen contents in plant tissues, phosphorus and nitrogen contents in the water body, pH, temperature, and salinity.

The luxuriant growth of water hyacinth was observed during the study period, which occurred with the temperature ranging between 26-32 ^{0}C, pH from 6.67-7.76, salinity from 0-1.5 ppt and water nutrients from 4.6-17.4 mg N/l, 0.18-0.70 mg NO_3-N/l and 0.14-0.93 mg P/l and 0.02-0.16 mg PO_4-P/l respectively. Under such conditions, results revealed that hyacinth plants produced a biomass yield of 20 –1800 g dry weight/m^2 and the number of plants increased from 21 to 412 per m^2 for the entire study period of 14 weeks with doubling time of around 13-15 days. The biomass production rate varied from 2.10-75.25 g dry weight/m^2 per day. Results of heavy metal uptake experiment suggest that rhizofiltration (metal absorption into roots) and phytoextraction (concentrate into the harvestable parts of roots or shoots) are the key mechanisms for removal of heavy metals from the aqueous phase. Phytoextraction was more responsible in translocating heavy metals to aboveground parts in initial few weeks and rhizofiltration became prominent at the later stages in which more metals are bound to below-ground parts. Once the heavy metal binding was complete, harvesting was suggested at the end of the 13th week during which more metals were adsorbed only to root zone.

From this study it was shown that there exists a massive proliferation of water hyacinth stands in Bolgoda Lake with a great influence of nitrogen, phosphorus, pH and temperature. However, there has been a significant perishment of the existing

stands of the vegetation from time to time due to the exposure to saline waters entering from the tidal action.

A numerical model was developed to simulate the growth of water hyacinth in Bolgoda Lake, Sri Lanka. The model was first applied to experimental data from Sato and Kondo, (1981). Secondly, it was used to evaluate the management options to control the growth of water hyacinth in Bolgoda Lake. Model application showed how the model could be used to evaluates the management options to control the growth of water hyacinth and to reduce the available nutrients in the system. These options include harvest strategies (initial density and harvesting interval) and harvest rate. The maximum yield of 329 g / m^2 dry weight was obtained when the rate of harvest was analogous to the initial density (at 100 g dry wt/m^2) in that the water hyacinths were harvested at a uniform rate every 20 days. The continuous harvesting is the major objective criteria to remove available nutrients in the water body and to control the excessive growth of water hyacinth in Bolgoda Lake.

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LIST OF ABBREVIATIONS

Abbreviations	Name
Nitrate-N	Nitrate Nitrogen
Phosphate-P	Phosphate Phosphorus
Dw	Dry weight
Ww	Wet weight
ppt	Parts per thousand
T	Temperature
Cd	Cadmium
Cr	Chromium
Co	Cobalt
Cu	Copper
Pb	Lead
Ni	Nickel
Nitrate-N	Nitrate Nitrogen
Phosphate-P	Phosphate Phosphorus
$b_{sht}(i)$	Dry weight of above-ground biomass at ith layer
B_{rt}	Root biomass
$Pg_{sht}(i)$	Gross growth rate of shoots at the ith layer
R_{sht}	Respiration rate of shoots
R_{rt}	Respiration rate of roots
D_{sht}	Mortality rate of shoots

Abbreviations	Name
D_{rt}	Mortality rate of roots
G_{rt}	Supply of photosynthesized material for root growth
H_{sht}	Harvesting rates of shoots
H_{rt}	Harvesting rates of roots
B_{sht}	Total shoot biomass
N	Number of layers in the plant canopy
Pg_{mx}	Maximal photosynthetic growth rate
$f(T)$	Dependency of growth on the temperature
$f(I)$	Response of shoots of water hyacinth to light intensity as a function
$f(N)$	Nitrogen limitation
$f(P)$	Phosphorus limitation
I_{PAR}	Photosynthetically active radiation
k_c	Light extinction coefficient within the canopy
K_{PAR}	Half saturation irradiance
F_i	Cumulative leaf area index of the stand above the layer I
N	Concentration of inorganic nitrogen
P	Concentration of phosphors in water
K_N	Half saturation constant for nitrogen

Abbreviations	Name
	uptake
K_P	Half saturation constant for phosphors
	Uptake
g_m	Maximum specific growth rate of roots
K_{rt}	Half saturation coefficient of root age
Age	Age of roots
β_{sht}	Rate coefficients for respiration of shoots
β_{rt}	Rate coefficients for respiration of roots
^{0}C	Centigrade
mt	metric tons
HCL	Hydrochloric acid

LIST OF SYMBOLS

Symbol	Name
θ	Arrhenius constant